

SECTION 34 11 37

DIRECT FIXATION FASTENERS

PART I - GENERAL

1.01 SECTION INCLUDES

- A. Standard Direct Fixation Fasteners (DF).
- B. Special Trackwork Resilient Ties (SPDF).

1.02 RELATED SECTIONS

- A. Refer to Section 34 05 17 - Common Work Results for Trackway, for related requirements.

1.03 MEASUREMENT AND PAYMENT

- A. General: Direct fixation fasteners will not be measured separately for payment. All costs in connection therewith will be considered as included in the applicable Contract lump sum price or the Contract unit price per linear foot for trackwork of the different types indicated as listed in the bid item in the Bid Schedule of the Bid Form.

1.04 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. ANSI B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)
 - 2. ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability
 - 3. ANSI B18.2.1 Square and Hex Bolts and Screws (Inch Series)
 - 4. ANSI B18.21.1 Lock Washers (Inch Series)
 - 5. ANSI B18.22.1 Plain Washers
- B. American Society for Testing and Materials (ASTM):
 - 1. A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 2. ASTM A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
 - 3. ASTM A36/A36M Standard Specification for Carbon Structural Steel
 - 4. ASTM A536 Standard Specification for Ductile Iron Castings
 - 5. ASTM A615/A615M Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
 - 6. ASTM A775/A775M Standard Specification for Epoxy-Coated Reinforcing Steel Bars

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7.	ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
8.	ASTM B695	Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
9.	ASTM C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
10.	ASTM D257	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
11.	ASTM D297	Standard Test Methods for Rubber Products-Chemical Analysis
12.	ASTM D395	Standard Test Methods for Rubber Property-Compression Set
13.	ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
14.	ASTM D429	Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates
15.	ASTM D471	Standard Test Method for Rubber Property-Effect of Liquids
16.	ASTM D518	Standard Test Method for Rubber Deterioration-Surface Cracking
17.	ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
18.	ASTM D624	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
19.	ASTM D1149	Standard Test Method for Rubber Deterioration-Surface Ozone Cracking in a Chamber
20.	ASTM D1193	Standard Specification for Reagent Water
21.	ASTM D1229	"Standard Test Method for Rubber Property-Compression Set at Low Temperatures"
22.	ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable
23.	ASTM D1566	Standard Terminology Relating to Rubber
24.	ASTM D2084	Standard Test Method for Rubber Property-Vulcanization Using Oscillating Disk Cure Meter

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| 25. | ASTM D2240 | Standard Test Method for Rubber Property-Durometer Hardness |
| 26. | ASTM E10 | Standard Test Method for Brinell Hardness of Metallic Materials |
| 27. | ASTM E23 | Standard Test Methods for Notched Bar Impact Testing of Metallic Materials |
| 28. | ASTM E162 | Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source |
| 29. | ASTM E662 | Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials |
| 30. | ASTM F436 | Standard Specification for Hardened Steel Washers |
- C. National Association of Corrosion Engineers (NACE):
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|-------------|---|
| NACE RP0188 | Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates |
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- D. Society of Automotive Engineers (SAE):
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| 1. | SAE J429 | Mechanical and Material Requirements for Externally Threaded Fasteners |
| 2. | SAE J434 | Automotive Ductile (Nodular) Iron Castings |
- E. Steel Structures Painting Council (SSPC):
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| 1. | SSPC SP1 | Solvent Cleaning |
| 2. | SSPC VIS 1 | Visual Standard for Abrasive Blast Cleaned Steel (Standard Reference Photographs) |
- F. Rubber Manufacturers Association, Inc. (RMA):
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| RMA Publication | Rubbers Handbook |
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1.05 SUBMITTALS

- A. Refer to Section 01 33 00 - Submittal Procedures, and Section 01 33 23 - Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.
- B. Refer to Section 34 05 17 - Common Work Results for Trackway, for additional submittal requirements.
- C. Provide additional submittals as required herein.

- D. Submit design drawings, material specifications, laboratory test results, and fabrication procedures in sufficient detail to demonstrate conformance or equivalence with the Contract requirements herein.

1.06 DESIGN SUBMITTALS

- A. Separate submittals are required for DF and SPDF fasteners.
- B. Prior to manufacture of fasteners for qualification testing submit the following for review and approval.
 - 1. Shop Drawings of each of the various fasteners, standard rail clip, special rail clip, anchorage assembly and shims, which detail each fastener component separately before assembly and the completely assembled fastener assembly. Drawings shall include all necessary dimensions, manufacturing tolerances and material descriptions for manufacturing the components as well as a table listing all components shown by name and by part number. Part numbers shall be assigned to fastener components and to finished assemblies. All parts identified by the same part number shall have the same physical dimensions, material composition, performance characteristics and durability.
 - 2. Method for identifying each lot and fastener as detailed herein.
 - 3. Installation and replacement procedures as detailed herein.
 - 4. Manufacturing plan as detailed herein.
- C. All submittals shall be made in accordance with the approved schedule to allow sufficient time for review and approval of resubmittals, if required, prior to manufacture of fasteners for qualification testing.
 - 1. Preliminary Shop Drawings shall be submitted. Final Shop Drawings shall be submitted 30 days prior to commencing qualification testing.
 - 2. Lot and Fastener Numbering System.
 - 3. Installation Procedure.
 - 4. Manufacturing Plan.
- D. Quality Program Plans.
 - 1. Quality assurance/control plan as specified herein.
 - 2. Test program plan as specified herein.
- E. Qualification Test Results.
 - 1. Submit the following for review and approval prior to commencing fastener manufacture.

- a. Certification of the elastomer samples used in qualification testing as detailed herein.
 - b. Elastomer qualification test results for each test specified in herein.
 - c. Anchorage assemblies qualification test results for each test specified in herein.
 - d. Fastener body metal qualification test results for each test specified herein.
 - e. Fastener assemblies qualification test results for each test specified herein.
 - 2. Submit qualification test results within 14 days after completion of testing. Submit elastomer certification with the elastomer qualification test results.
- F. Production Test Results.
- 1. Submit the following for review and approval prior to shipping each fastener production lot.
 - a. Certification of the elastomer samples used in the production testing of each production lot as detailed herein.
 - b. Elastomer production test results for each test specified herein.
 - c. Anchorage assemblies production test results for each test specified herein.
 - d. Fastener production test results for each test specified herein.
 - 2. Submit production test results within fourteen days after completion of testing. Submit elastomer certification with the elastomer production test results.
- G. Submit the method of packaging, loading, shipping and handling the fasteners, rail clips and anchorage assemblies for review and approval prior to the initial shipment. Submit the methods no later than 60 days prior to the initial shipment.
- H. Submit record drawings, which incorporate all Engineer-approved changes into the fastener Shop Drawings, for review and approval within 15 days of the final fastener delivery and prior to acceptance of the last product.
- I. Submit sample DF and SPDF of each type and anchorage assemblies, complete with associated hardware and shims five days prior to commencing qualification testing. Submit direct fixation fasteners and anchorage assemblies, and shims in the quantities indicated herein.

1.07 QUALITY CONTROL

- A. The Contractor shall submit establish, implement and maintain a detailed Quality Plan in conformance with applicable requirements of Section 01 43 00 - Quality Assurance, and Section 01 45 00 - Quality Control.
- B. In addition to the other requirements herein, the plan shall include the following.

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1. Material specifications; certificates of compliance for all components.
2. Process control.
3. Quality control testing procedures and frequency.
4. Vendor (sub-supplier) surveillance.
5. Corrective action and disposition of defective components.
6. Delivery protection and handling.
7. Identification.
8. Acceptable quality levels and sampling plans.

C. Tolerances.

1. Manufacturing tolerances for the fastener shall be as shown in Table 1.

Table 1 - Direct Fixation Fastener Manufacturing Tolerances	
DIMENSION	TOLERANCE
Length and width	$\pm 1/16$ inch.
Height	$\pm 1/32$ inch.
Squareness	All angles shall be within ± 0.5 degree.
Centering of holes	$\pm 1/32$ inch.
Diameter of holes	$\pm 1/32$ inch.
Durometer Shore A	± 5 .
Serration depth	$\pm 1/32$ inch.
Serration spacing	$\pm 1/32$ inch.
Width between shoulders at rail base	$\pm 1/32$ inch.
Rail seat area flatness measured from a straight edge placed across the rail seat area	Less than 0.050 inch.

2. Forming tolerances for the concrete test block used for fastener tests shall be as follows.

- a. The concrete surface flatness shall have a maximum 1/16 inch gap between 16 inch straight-edge and concrete surface all around.
 - b. The elevation of top face of anchorage insert embedded in concrete shall be 0 inch above or 1/16 inch below top surface of concrete.
 - c. No void in bearing surface of concrete shall be greater than 1/2 inch and total area of voids shall be less than 10 percent of total fastener bearing area.
- D. Approval of the fastener design will be dependent upon successful completion of the qualification testing program specified herein.
- E. All fastener testing and inspection shall be performed by a qualified, independent testing laboratory approved by the Engineer. The selected laboratory shall use the proper equipment and qualified testing personnel for the testing and inspection described in these Specifications. Fastener testing and inspection equipment and personnel shall be subject to approval by the Engineer. The Engineer, or an independent witness designated by the Engineer, will monitor the operations at the testing laboratory to ensure that the inspections and tests are being performed in accordance with approved procedures and in compliance with these Specifications.
- F. Personnel performing tests and inspections shall be qualified for such work by virtue of prior experience or training.
- G. Testing equipment shall be in good operating condition, of adequate capacity and range, and accurately calibrated. Testing equipment calibration shall be certified and traceable to recognized national standards such as the National Institute of Standards and Technology. Testing equipment shall be calibrated in accordance with the schedule in the approved Quality Plan specified in Section 01 45 00 - Quality Control.
- H. Test Program Plan.
1. A test program plan shall be prepared describing the approach for accomplishing each of the specified fastener inspections and tests. A detailed narrative shall be prepared for each test and inspection specified herein, describing the test set-up; equipment, and instrumentation that will be used; procedure to be implemented; and the anticipated, as well as acceptable test results. Drawings detailing test equipment and test set-up of fastener or fastener component that will be tested shall be included. Drawings shall show the relationship of the fastener or fastener component and all significant components of the testing equipment, including the test block. Pertinent testing drawings included in industry standard specifications herein may be referenced in lieu of actual drawings. The test program plan shall include the test sequencing.
 2. Equipment specifications and calibration methods for all testing equipment used to perform fastener testing and inspection shall be included in the test program plan. The plan shall indicate the calibration certificates that will be submitted with the test reports.
 3. Identity and qualifications of personnel who will perform fastener testing and inspection shall be included in the test program plan. Also include certification records for personnel who will perform nondestructive testing.

4. The test plan shall include the name and location of the testing facility, qualifications of the testing facility, a description of the testing facilities, and a layout of the test equipment that will permit efficient performance of the testing.
5. The plan shall include the proposed format for reporting test data.
6. The projected schedule for test procedure submittals, test execution, and test result reports submittals shall be included in the test program plan.
7. The test program plan shall address qualification testing and production testing separately. Elastomer, anchorage assemblies, fastener body metal, and fastener assemblies shall also be addressed separately.
8. After approval of the test program plan, any proposed changes shall be approved by the Engineer prior to implementing the change.

I. Test Report.

1. A report of test results of each test shall be submitted which includes test name, identity of test sample, original data calculations, test procedure references, test equipment identification, test personnel, time and date of test, specified requirements, actual test results, non-conformances if any, and interpretation of the results. The format for the test report shall be arranged so that the data is presented in an orderly manner.
2. Accompanying the written test reports shall be a photographic record of the tests. The photographic record shall contain photographs of sufficient clarity to distinguish relevant details as described or referenced in the respective written report.
3. Copies of calibration certificates shall be submitted with the initial test results. If test equipment is recalibrated while work is being performed on this Contract, calibration certificates shall be submitted for the recalibrated test equipment with the test reports of the first tests performed after recalibration.
4. The Engineer shall be notified in writing not less than seven days in advance of dates scheduled for any tests or inspections. The Engineer retains the right to witness the tests.

J. The Contractor shall prepare a manufacturing plan including.

1. An activity network delineating each step of production that will produce the fastener configuration shown on the approved Shop Drawings and made of the approved materials.
2. A narrative shall be included describing each activity. Special attention shall be given to key procedures such as curing temperature, curing time, molding pressure and heat treating.
3. A list of all company names and locations of any plant or subcontractors plant where work will be performed on any fastener or component part of any fastener. This list shall show what type or work function each company shall perform. Off the

shelf, standard products such as bolts and nuts, need not show manufacturing location, but must show the company name and address from which it is proposed to be purchased.

1.08 DIRECT FIXATION FASTENER QUALIFICATION TESTING

A. General

1. Qualification tests shall be performed prior to fastener production to verify that the proposed fastener, fastener components, and fastener materials meet the requirements of these Specifications.
2. Test in accordance with the approved test program plan and test procedures.

B. Approval

1. All qualification tests conducted on fasteners, fastener components, and fastener materials shall be successfully completed to the approval of the Engineer prior to commencing any production of fasteners or fastener components.
2. After the Engineer has approved the fastener design, no change in the fastener design, fastener components, fastener materials, and manufacturing process shall be made without written approval of the Engineer. Should the Contractor propose a change, the Engineer may require retesting of the rail fastener as altered. All such testing shall be performed in the same laboratory on the same equipment and insofar as possible by the same laboratory personnel as the qualification tests.

1.09 ELASTOMER QUALIFICATION TESTING

A. Test Samples

1. Test samples shall be certified to have been taken from a batch of compound used for making the elastomer components of the fastener and having an equivalent degree of cure to the cure of the elastomer component.
2. Prior to testing, all samples shall be conditioned for not less than two days or for the time period indicated in each specified ASTM standard, whichever is greater, at 23 degrees C +/- 2 degrees C and 50 relative humidity +/- 5 percent.

- B. Perform the following tests on each of two specimens that are identical in all respects to the elastomer proposed for use in the direct fixation rail fasteners. Use a separate pair of specimens for each test.

C. Hardness Test

1. Measure the elastomer in accordance with ASTM D2240.
2. The durometer of the elastomer, measured on the Durometer A scale, shall be between 40 and 70.

D. Tensile Strength and Ultimate Elongation Tests

1. Test the elastomer in accordance with ASTM D412 to determine the tensile strength and the ultimate elongation.
 2. The tensile strength shall be 2500 psi or greater and the ultimate elongation shall be 500 percent or greater.
- E. High Temperature Compression Set Test
1. Test the elastomer for 22 hours in accordance with ASTM D395, Method B. The test shall be conducted at a temperature of 70 degrees C.
 2. The set shall not exceed 25 percent.
- F. Compression Set at Low Temperature Test
1. Test the elastomer at minus 10 degrees C for 70 hours in accordance with ASTM D1229, to determine the percent compression set at 30 minutes after release (t_{30} reading).
 2. The compression set shall not exceed 65 percent.
- G. Accelerated Aging of Rubber Test
1. Age the elastomer for 70 hours at 70 degrees C in accordance with ASTM D573. Measure and record the change in hardness and percentage change of properties from the original tensile strength and ultimate elongation.
 2. The percentage of decrease of tensile strength shall not exceed 25 percent; the percentage of decrease of ultimate elongation shall not exceed 25 percent; and the change in hardness, measured on the Durometer A scale, shall not exceed 10 points.
- H. Resistance to Ozone Cracking Test
1. Prepare test specimens in accordance with Procedure A of ASTM D518. Test the specimens in accordance with ASTM D1149 at a temperature of 40 degrees C and at an ozone concentration of 50 mPa.
 2. The elastomer shall not exhibit any cracking when examined in accordance with ASTM D1149 at the end of a 100 hour exposure.
- I. Oil Absorption Test
1. Determine the volume change of the elastomer using ASTM D471. Conduct one test with ASTM No. 3 oil at a temperature 23 degrees C for 70 hours and conduct the other test using a different sample with ASTM No. 1 at a temperature of 23 degrees C for 70 hours.
 2. The volume change for the No. 1 oil shall not exceed 20 percent; and for No. 3 oil, the volume change shall not exceed 100 percent.

J. Adhesion to Metal Test

1. Test the elastomer's adhesion to the metal top and base elements as per ASTM D429 Method B. Use the same metal, metal preparation, elastomer, adhesives and bonding process in preparing the test specimen as are used in the production of the fasteners body.
2. The failure shall be a Type R, in which the elastomer tears before the elastomer bond to the metal parts fails. The adhesion value shall be a minimum of 35 pounds per inch width.

K. Flame Spread and Smoke Generation Test

1. Test the elastomer in accordance with ASTM E162 to determine the flame propagation index. Test the elastomer in accordance with ASTM E662 in both the flaming and non-flaming modes to determine the smoke generation specific optical index.
2. The elastomer shall not exhibit flaming drippings when tested. No acceptance criteria are specified for the flame propagation index and the smoke generation specific optical index. Report these indices to the Engineer for information only.

L. Electrical Resistivity Test

1. Test the elastomer in accordance with ASTM D257.
2. The elastomer shall have a minimum volume resistivity of $10^{12} \Omega \cdot \text{cm}$.

M. Water Absorption Test

1. Determine the volume change of the elastomer due to absorption of water using ASTM D471. Use Type IV reagent water in accordance with ASTM D1193. Immerse the specimens for 70 hours at a temperature of 70 degrees C.
2. The elastomer shall have a maximum increase in volume of five percent.

N. Tear Resistance Test

1. Test the elastomer in accordance with ASTM D624. Utilize Die C specimens.
2. The resistance to tearing shall not be less than 150 pounds per inch.

O. Rheology (Cure and Strength Indicator) Test

1. Test the elastomer in accordance with ASTM D2084.
2. During qualification testing a cure curve shall be developed based on the rheology test results for approval by the Engineer. Specification limits shall be established at several points along the curve for approval by the Engineer.
3. During production testing the cure curves shall be compared to the qualification test cure curve. The production test curve shall be within the specification limits.

P. Specific Gravity Test

1. Test the elastomer in accordance with ASTM D297.
2. During qualification testing the specific gravity of the elastomer shall be determined. During production testing the specific gravity shall be plus or minus 0.02 of the specific gravity determined during qualification testing.

1.10 ANCHORAGE ASSEMBLIES QUALIFICATION TESTING

A. For the acceptance of anchorage design, each anchorage assembly shall satisfy the test requirements and the test results shall not be averaged.

B. Test Preparation

1. The anchorage inserts shall be embedded in a reinforced concrete test block. The test block size and configuration shall conform to one of the two test blocks shown in Figure 2. The size and configuration of the test block shall be determined by the Contractor, subject to approval by the Engineer. The sides shall be vertical and the top and bottom shall be horizontal. The inserts and reinforcing steel shall be positioned as they would be in track. The inserts shall be vertical, with the top face flush with the concrete surface. The inserts shall be set in the concrete before or during the concrete placing. Post-drilling and placing of inserts with resins or grouts shall not be permitted.
2. The concrete test block shall have a compressive strength of 4,000 to 6,000 pounds per square inch as determined by ASTM C39. The tests on the inserts shall not begin until the concrete has reached the specified compressive strength.
3. The reinforcing steel shall be placed as shown on Figure 2. Use ASTM A615/A615M, Grade 60 steel.
4. The anchor bolts shall be threaded into the inserts to at least 1-1/2 inch thread engagement before load application.
5. The number of test blocks required to perform the anchorage assemblies qualification testing shall be determined by the Contractor, subject to approval by the Engineer.

C. Qualification Tests

1. Eight anchorage assemblies identical in design to those specified for supply with the fasteners shall be required to perform the tests specified herein.
2. Two separate anchorage assemblies shall be used for each of the three tests.

D. Restrained Pullout Test

1. Place a 8 inch by 8 inch by 1/2 inch steel plate with a 3 1/2 inch diameter hole in its center, centered over an anchor bolt. Apply for one minute an upward vertical load, starting at 1,000 pounds and increasing to 40,000 pounds, to the anchor bolt with the

reaction force bearing against the steel plate. Repeat the test on one other anchor bolt.

2. There shall be no evidence of slippage or cracking of concrete or failure of bond between either of the two bolts or inserts, and concrete.

E. Unrestrained Pullout Test

1. Apply a vertical pullout load on an anchor bolt, in such a manner that no restraining load is applied to the concrete within a radius of 6 inches from the center of the bolt. The load application shall start at 1,000 pounds, be increased until a load of 12,000 pounds occurs, be held at 12,000 pounds for at least one minute and be released. Inspect the test block for evidence of concrete cracking or failure of bond between bolts or inserts, and concrete. Repeat the test on one other anchor bolt.
2. After successful completion of the Unrestrained Pullout Test, reapply a vertical pullout load as specified in herein. The load application shall start at 1,000 pounds and be increased until fracture of the concrete test block. Inspect the anchor bolt and anchor insert for evidence of failure.
3. There shall be no evidence of concrete cracking or failure of bond between either of the two bolts or inserts, and concrete when tested to a 12,000 pound pullout load.
4. There shall be no evidence of insert fracture, or bolt or insert thread stripping when tested to fracture of the concrete test block.

F. Torsion Test

1. An anchor bolt shall be subjected to a torque at least 100 percent greater than the design installation torque submitted with the installation requirements specified herein. The load shall be held for three minutes and released. Repeat the test on one other anchor bolt.
2. There shall be no evidence of failure of the bond between either of the two bolts or inserts, and concrete.

1.11 BODY METAL QUALIFICATION TESTING

A. Charpy Impact Test

1. The Charpy impact test specified herein shall be performed on three samples of metal to be used for the metal top and base elements of the fastener body. Each metal sample shall have met the minimum impact requirements and be approved by the Engineer before fastener assembly qualification testing proceeds.
2. Prepare three Charpy impact test specimens in accordance with ASTM E23 from the same metal used for the top and base elements of the fastener body. If different grades of steel or iron are used for the two elements, prepare three specimens of each. Conduct a charpy impact test on each specimen at a temperature of 21 degrees C in accordance with ASTM E23. The test report shall include all the information required by ASTM E23.

3. The fracture energy shall be greater than 3 foot-pounds for irons and 15 foot-pounds for steel.

B. High Frequency Resonance Test

1. Suspend the top plate with a nylon, hemp, polyethylene or cotton rope; or an elastomer band of sufficient strength to support the top plate without failure. Mount an accelerometer of mass not greater than 0.05 kg at the center of the rail seat area, with an axis of sensitivity normal to the rail seat. The accelerometer signal shall be appropriately conditioned with a charge amplifier or voltage preamplifier and analyzed with a minimum 400 line spectrum analyzer, while striking an end of the top plate with a hammer in a direction normal to the rail seat plane.
2. The frequencies of the top plate's modes of vibration, identified by maxima in the spectrum of the response of the top plate to hammer impacts, shall be greater than 600 Hz.

1.12 FASTENER QUALIFICATION TESTING

A. General

1. Following review and approval of the Shop Drawings, installation procedure, manufacturing plan, test program plan and Quality Plan by the Engineer, a minimum of eight complete fastener assemblies and 12 shims shall be manufactured for qualification testing. From these, the Engineer shall select four fasteners and eight shims at random for testing. The selected fastener assemblies and shims shall be assembled and installed on the concrete test block for testing. The remaining four fastener assemblies and four shims shall be delivered to the Engineer to be retained for control reference of dimensional tolerances and surface appearance of fasteners subsequently manufactured and further test use.
2. If the two-fastener alternative testing arrangement is selected, the quantities of fasteners and shims required shall be revised. A minimum of 16 complete fastener assemblies and 24 shims shall be manufactured. From these, eight fastener assemblies and 16 shims shall be selected by the Engineer at random for testing, and eight fastener assemblies with eight shims shall be delivered to the Engineer.

B. Test Preparations

1. Except as described herein, a minimum of four complete fastener assemblies are required to conduct the tests. Each fastener shall be carefully measured and examined to determine their compliance with the approved Shop Drawings and these Specifications. Upon satisfactory completion of this measurement and examination, each fastener shall be assembled and designated as Fastener A, B, C, and D. Each fastener shall be mounted on a concrete test block and the tests conducted in sequence, in accordance with Figure 3.
2. Except as otherwise specified herein, each test shall be performed on a completely assembled fastener with a section of 119RE rail not less than one foot long mounted and clipped thereon. Before assembly, metal parts and elastomer shall be wiped clean and dry. The fasteners shall be assembled as shown on the test apparatus working drawings, as approved by the Engineer and as outlined in the approved test

procedures. The fasteners shall be assembled with the rail in the middle lateral adjustment setting. One 3/8-inch shim shall be placed under the fastener. The anchor bolts shall be tightened to the design installation torque submitted with the installation procedures approved by the Engineer. The torque of each bolt shall be measured and noted in the test report.

3. The concrete test block shall be one of the two test blocks herein, subject to approval by the Engineer.
4. Before commencing each test, the fastener and concrete test block shall be stabilized at a temperature of 23 degrees C, +/- 4 degrees C, for at least four hours, except as otherwise specified herein. Testing shall be performed within the same temperature range, except as otherwise specified herein.
5. Except as otherwise specified herein, the test loading shall be applied to the rail at the centerline of the fastener. Each fastener shall be distinctly labeled and the test report shall clearly indicate the performance of each of the fasteners (Fastener A, B, C and D) separately. For acceptance of the fastener design, each fastener shall satisfy the test requirements without failure.
6. The number of test blocks required for the qualifications testing shall be determined by the Contractor, subject to approval of the Engineer.
7. Linear voltage displacement transducers may be used instead of dial gauges to measure displacements.

C. Alternative Test Preparations

1. Instead of using one fastener, each test may be performed on a pair of fastener assemblies with a section of 119RE rail not less than 30 inches long mounted and clipped thereon. The minimum edge-to-edge spacing between fasteners shall be 6 inches. Each fastener shall be assembled and mounted as described herein for one fastener. Fasteners shall be designated as Fastener A1 and A2, B1 and B2, C1 and C2, and D1 and D2. Tests shall be conducted in sequence in accordance with Figure 3.
2. For the two-fastener testing arrangement, the loadings specified for each test shall be doubled and applied to the rail at a point centered between the fasteners to ensure that each fastener is equally loaded. Each fastener in the pair shall be distinctly labeled and the test report shall clearly indicate the performance of each fastener (Fastener A1 and A2, B1 and B2, C1 and C2, and D1 and D2) separately. For the acceptance of fastener design, each fastener shall satisfy the test requirements without failure.
3. The concrete test block shall be prepared as herein, subject to approval of the Engineer.

D. The following tests shall be performed in the sequence shown on Figure 3.

E. Vertical Load Test

1. The fastener shall be vertically loaded to 18,000 pounds for one minute. Thereafter, the load shall be released, and, after one minute, displacement gauges, one on each side of the load, shall be zeroed at zero load. A vertical load increasing in increments of 1,000 pounds to a maximum load of 18,000 pounds at a rate not less than 100 pounds per minute and not more than 1,000 pounds per minute, shall be applied downward at the centerline of the rail head at the centerline of the fastener and normal to the rail. For each increment of load at 1,000 pounds and above, measure and record the vertical deflection of the rail head to the nearest 0.001 inch with each displacement gauge. The load shall be removed and the final position of the rail head measured and recorded to the nearest 0.001 inch with each displacement gauge.
2. Acceptance Criteria
 - a. The fastener stiffness, defined as the slope of a straight line determined by standard linear least squares regression of the load versus deflection with load as the dependent variable, or response, and deflection as the independent variable over the load range of 4,000 to 12,000 pounds per fastener shall be within 15 percent of 108,000 pounds per inch. The tangent to the load versus deflection curve at each load between and including 4,000 pounds and 12,000 pounds shall be within 20 percent of the actual fastener stiffness determined above. For the purpose of calculation, the tangent to the load versus deflection curve at (X_n, P_n) shall be approximated as: $(P_{n+1} - P_{n-1}) / (X_{n+1} - X_{n-1})$; Where P_i is the load at deflection X_i . The deflection X_i shall be the average of the two displacement gauge readings.
 - b. The total compressive deflection of the elastomer at the 14,000 pounds load shall not exceed 25 percent of the uncompressed thickness. After removal of the maximum load of 18,000 pounds, the fastener shall return to within 0.005 inch of its original position within 1 minute. At no time during the tests shall a fastener component exhibit any sign of failure by slippage, abrasion, yielding, fracture, or bond failure. Slippage is defined herein to mean movement of any fastener component relative to its initial position not attributable to deflection of the elastomer.
 - c. The values obtained when the test is repeated on same fastener, after performance of other tests shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

F. Vertical Uplift Test

1. Continuously apply a vertical load of 2000 pounds to the center line of the rail head at the centerline of the fastener normal to the rail, alternating continuously from a downward direction load to an upward direction load. The load shall be applied at a constant rate, between two and four minutes per cycle. Each cycle shall be from zero load to maximum compression, to maximum tension, and back to zero load. The fastener shall be preconditioned for not less than six complete cycles. After the preconditioning cycles, the test shall be run without pause for not less than 10 complete cycles. The loads and corresponding deflections shall be continuously measured to the nearest 0.001 inch and immediately recorded on a load-versus-time

graph and a deflection-versus-time graph, respectively. Recording shall be accurate within two percent of full scale readings. Remove the load and measure and record the final position of the rail head. The reaction force to the uplift load shall be applied to the test block on which the fastener is mounted. The test report shall include load-deflection, load-time, deflection-time, and calibration recordings.

2. Acceptance Criteria

- a. The vertical deflection of the fastener for an upward load of 2,000 pounds shall be within plus five percent to plus 135 percent of the deflection for the 2,000-pound downward vertical load. When the vertical load is continuously varied from vertical downwards to vertical upwards, there shall be continuity and uniformity of the load/deflection curve with no indication of backlash or freeplay as the vertical load goes from downward directed to upward directed. After removal of the maximum upward test load and again after removal of the maximum downward test load, the rail head shall, within one minute, return to within 0.005 inch of its original rail head position. At no time during the test shall any fastener component, including the anchorage to the test block, exhibit any sign of failure by slippage, abrasion, yielding, fracture, or bond failure.
- b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

G. Lateral Load Test

1. While applying a constant vertical load of 14,000 pounds downward at the center of the rail head, a lateral load, increasing in increments of 500 pounds to a maximum load of 6,000 pounds at a rate not less than 100 pounds per minute and not more than 1,000 pounds per minute, shall be applied horizontally to the gauge side of the rail head at the point of vertical load. The horizontal force shall be applied 0.625 inch below the top of the rail. For each load increment the lateral deflection of the rail head at a point 0.625 inch below the top of the rail shall be measured to the nearest 0.001 inch and recorded. Remove the lateral load and measure and record the final position of the rail head.

2. Acceptance Criteria

- a. The lateral load versus deflection curve shall lie within the envelope shown in Figure 4 for the operating range of 1000 to 4000 pounds of lateral load. After removal of load, the difference between the original and final position of the gauge line shall not exceed 0.062 inch. At no time during the test shall any fastener component exhibit a sign of failure by slippage, abrasion, yielding, fracture, or bond failure.
- b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

H. Lateral Restraint Test

1. Two equal lateral loads increasing simultaneously in increments of 500 pounds up to a maximum load of 3000 pounds shall be applied normal to the rail in the same direction and at the base of the rail. Loads shall be symmetrical on each side of the fastener centerline. The lateral deflection shall be measured to the nearest 0.001 inch at the intersection of the centerline of the fastener and the gauge line of the rail. Measurements shall be recorded after each increment of loading.
2. Acceptance Criteria
 - a. The difference between the original and final positions of the gauge line after removal of the load shall not exceed 0.062 inch. The lateral deflection of the rail when fully loaded shall not exceed 0.125 inch from the original gauge line of the rail. At no time during the test shall any fastener component show signs of failure by slippage, abrasion, yielding, fracture, or bond failure.
 - b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein and shall be within 15 percent of the initial test values.

I. Longitudinal Restraint Test

1. Apply a load longitudinally to the rail at its centroid increasing in increments of 200 pounds up to a total load of 4,000 pounds or until the rail deflects 0.6 inch from the initial position. Maintain each load increment constant until the longitudinal deflection of the rail ceases before increasing the load by the next increment. For each load, measure and record the longitudinal deflection of the rail to the nearest 0.001 inch. Then remove the longitudinal load and measure and record the final position of the rail. Plot the recorded values for longitudinal load versus deflection on a graph as shown on Figure 4.
2. The longitudinal load versus deflection curve, when plotted on a graph similar to Figure 4, shall lie entirely within the limits shown shaded. At no time during the test shall a fastener component exhibit a sign of failure by slippage, yielding, or fracture, except for the slippage that occurs between the rail clips and the rail.

J. Voltage Withstand Test

1. Prepare a fully assembled fastener and with a dc Hi Pot tester apply a dc potential of 10 kV between the rail head and the metal base element of the fastener body for one minute.
2. The elastomer shall withstand this test with no visible damage such as splits, cracks, pinholes or fractures. There shall be no evidence of arcing, arc tracking, or other voltage breakdown.

K. Electrical Resistance and Impedance Test

1. Prepare a fully assembled fastener and apply 500 V dc to the rail head for three minutes with all anchor bolts and metal base element grounded. Measure the resistance between the rail and anchor bolt, in accordance with ASTM D257, with an accuracy of plus or minus two percent and record. Next, remove the fastener from the test block and immerse it in deionized water for 70 hours at 70 degrees C. Immediately after removal from the water immersion, without drying and with no portion of the fastener at a temperature less than 35 degrees C, reinstall the fastener on the test block and test for electrical resistance and impedance. With all anchor bolts and the metal base element grounded, apply 500 V dc to the rail head for three minutes. Measure the resistance with an accuracy of plus or minus two percent and record. Apply a potential of 50 V ac to the rail head for three minutes for each increment of measurement for frequencies from 20 Hz to 10 kHz in increments of 10 Hz up to 100 Hz, 200 Hz up to 1 kHz, and 2 kHz up to 10 kHz. The impedance after three minutes shall be measured with an accuracy of plus or minus 2 percent and recorded for each frequency.
2. Acceptance Criteria
 - a. The minimum resistance for 500 V dc shall be 10 M Ω when dry and 1 M Ω when wet. The minimum impedance for frequencies between 20 Hz and 10 kHz with 50 V ac shall be 10 k Ω when wet.
 - b. The values obtained when the test is repeated on same fastener, after performance of other tests, shall meet the acceptance criteria specified herein.

L. Corrosion Test

1. The rail fastener, and all associated but unassembled components, shall be exposed to a five percent chloride solution in accordance with ASTM B117 for 500 hours.
2. Acceptance shall be based upon visual comparison between actual metal surface condition after completion of the test and the pictorial surface preparation standards presented in SSPC VIS 1. The condition of the metal surfaces shall match or be superior to Rust Grade B, wherein there is no more than light surface rust, mill scale has only begun to flake. There shall be no evidence of edge bond deterioration. In areas where prior testing has removed the protective coatings, the surface rust grade specified above shall be used for judging acceptance.

M. Vertical and Lateral Repeated Load Test

1. Apply load on the rail head center so as to produce a vertical downward load of 14,000 pounds. Apply lateral loads to the gauge side of the rail head 0.625 inches below the rail head. Lateral loads shall be applied at the centerline of the fastener and normal to the rail. Lateral loads from the field side shall be 2,500 pounds and from the gauge side, 4,000 pounds. Application of the lateral loads shall be alternate, each combined with the application and release of the vertical load. Application of the field side load together with the vertical load, loads release and then the gauge side load together with the vertical load and loads release shall constitute one cycle. For the qualification testing program, the test shall be

conducted for 3 million cycles. The anchor bolts may be retorqued to their initial torsion once during this test prior to 500,000 cycles. The loading frequency shall be regulated to prevent the temperature of components from exceeding 50 degrees C. The rail clips shall not be repositioned nor threaded elements retorqued without written approval of the Engineer.

2. The fastener shall withstand the specified total number of cycles of load application with no evidence of failure. Upon visual inspection, no component of the fastener shall exhibit any evidence of failure by slippage, yielding, abrasion, fracture, or bond failure at any time during the test. The rail shall exhibit no evidence of wear or grooving that could contribute to failure of a rail. The rail clip shall not exhibit any evidence of vibrating loose from the rail clip holder.

N. Repeated Load Test With One Anchor Bolt Loosened

1. After completion of the vertical and lateral repeated load test, reassemble the fastener using only the original components previously tested. Then, with the gauge side anchor bolt loosened and backed out 1/4 inch, repeat the vertical and lateral repeated load test for 15,000 cycles.
2. The fastener shall withstand the specified total number of cycles of loading with no evidence of failure by slippage, yielding, abrasion, fracture, or bond failure. The rail shall exhibit no evidence of wear or grooving that could contribute to failure of a rail. The rail clip shall not exhibit any evidence of vibrating loose from the rail clip holder.

O. Uplift Repeated Load Test

1. Test Method
 - a. A fully-assembled fastener shall have loads applied to the rail head so as to produce alternately a vertical downward load of 14,000 pounds and a vertical upward load of 2,400 pounds at the centerline of the fastener normal to the rail. Apply the loads alternately for a total of 1.5 million complete cycles. The frequency shall be regulated to prevent component temperature reaching 50 degrees C. Do not reposition rail clips nor retorqued threaded elements without written approval of the Engineer.
 - b. During the final 500,000 cycles, a longitudinal load shall be applied to the rail at its centroid. Increase the load in increments of 100 pounds up to 600 pounds at intervals of at least one increment per 100 cycles of vertical loading. For each load increment, measure and record the longitudinal deflection of the rail to the nearest 0.001 inch. Then remove the longitudinal load and measure and record the longitudinal position of the rail. Plot the recorded values for the longitudinal load versus deflection on a graph.
2. The fastener shall withstand 1.5 million cycles of load application with no evidence of failure. Upon visual inspection no fastener component shall exhibit any evidence of failure by yielding, abrasion, slippage, fracture, or bond failure. The rail shall exhibit no evidence of wear or grooving that could contribute to its failure. The plot

of the load versus deflection curve shall indicate the elastic deformation and the residual deflection. The residual deflection shall not exceed 0.005 inch.

P. Dynamic to Static Stiffness Ratio Test

1. Test Method

- a. An oscillating downward load shall be applied at the centerline of the rail head at the centerline of the fastener so as to produce a sinusoidal load alternating between 2,000 and 6,000 pounds at a rate of between 10 and 20 Hz. The load and deflection versus time shall be continuously recorded on a high speed oscillograph. After a minimum of 1,000 cycles, the dynamic stiffness shall be determined from the ratio of peak-to-peak force to peak-to-peak deflection from the recorded information. The deflection shall be measured to an accuracy of 0.001 inch or better.
- b. Between five and 10 minutes after completion of the dynamic stiffness measurement, a vertical load increasing in 1,000-pound increments to a maximum load of 6,000 pounds, at a rate not more than 1,000 pounds per minute, shall be applied at the centerline of the rail head at the centerline of the fastener. For each increment of load between 2,000 and 6,000 pounds, record the vertical deflection of the rail head to the nearest 0.001 inch. The static stiffness of the fastener shall be the difference in load divided by the difference in deflection between 2,000 and 6,000 pounds.

2. The dynamic stiffness shall not exceed 1.5 times the static stiffness.

Q. Heat Aging Test

1. Age test the fastener body, without rail, concrete test block, rail clips or anchorage assemblies in an air oven. The fastener body shall be aged for 336 hours at a temperature of 70 degrees C as per ASTM D573.
2. This is a conditioning process and there is no acceptance criterion.

R. Fastener Qualification Failure

1. Should any fastener assembly fail a test, the entire sequence of tests, as specified, in which the failed test is included, shall be performed on a new fastener assembly.
2. If the fastener assembly must be modified to pass any test, Shop Drawings of the new design shall be submitted and approved by the Engineer before qualification testing is continued.
3. A new lot of at least eight rail fastener assemblies of the new Engineer-approved design shall be produced and all tests performed on the new fastener design.
4. The revision, approval and test cycle shall continue until fastener assemblies are approved, but no longer than 12 weeks after acceptance of the new design.
5. The cost of all such additional designing, manufacturing, and testing caused by failure of any component that does not comply with these Specifications, including

expenses for the Engineer to witness the tests, shall be at no additional expense to the District.

1.13 PACKAGING, LOADING, SHIPPING, AND HANDLING

- A. The Contractor shall submit a stockpile plan to the Engineer for approval that defines how the direct fixation fasteners and fastener components will be stacked and the area required.
- B. Direct fixation fasteners shall be lifted and supported during manufacture, storage, transportation, loading, unloading, and stockpiling in a way that will prevent tearing, separation, deformation, or other damage.
- C. Direct fixation fastener sets required for special trackwork units shall be packaged separately and each shall be marked with the special trackwork unit identification number, unique color coding and location number. Complete tie sets shall be first sent to the manufacturing facility of the special trackwork, for required complete preassembly prior to shipment to the District.

PART 2 - PRODUCTS

2.01 DISTRICT-FURNISHED MATERIALS

- A. Refer to Section 01 64 13 - District-Furnished Materials and Equipment, of the Contract Specifications for description and quantity of District-furnished materials.

2.02 CONTRACTOR-FURNISHED MATERIALS

- A. All products, tools, materials, equipment and labor required to complete all aspects of the work shall be furnished by the Contractor.

2.03 PRODUCTS AND MATERIALS

- A. The same brand, type and style of fasteners shall be used throughout.
- B. Fastener Dimensions
 - 1. When completely assembled with clips and anchors all parts of the fastener above the concrete trackbed shall stay within a design envelope 14-1/2 inches long minimum and 16 inches long maximum, measured horizontally perpendicular to the rail; and 7 inches wide minimum and 8 inches wide maximum, measured horizontally parallel to the rail. SPDF rail fastener lengths may vary, as recommended by the manufacturer, up to 72" long; the minimum number of different lengths shall be minimized.
 - 2. The height of the fastener body in the installed position measured vertically from the base of the fastener body to the base of rail at the rail centerline and excluding shims shall be no greater than 2 inches.
 - 3. No portion of the completely assembled fastener, including rail clips and anchor bolts, shall extend any higher than 4 inches measured vertically from the base of rail at the rail centerline.

4. The perpendicular-to-rail offset from centerline of anchor bolt to centerline of fastener shall be 5-1/4 inches. The parallel-to-rail offset from centerline of anchor bolt to centerline of fastener shall be 1-3/4 inches. In addition, the centerline of anchor bolt shall be no closer than 1-1/2 inches from any side.
5. When installed, no part of the anchorage insert shall extend into the track concrete deeper than 5-1/2 inches from the concrete trackbed surface.
6. The diameter of the fastener body and anchorage assembly component holes through which the anchor bolt passes shall not be less than 0.895 inch nor more than 0.938 inch.
7. With the rail clips removed from the otherwise assembled fastener, no portion of the fastener shall extend any higher than 1-1/2 inches above the base of rail, as measured vertically from the base of rail at the rail centerline.
8. These and other dimensional requirements are shown graphically on Figure 1.

C. Specific Fastener Requirements

1. The fasteners shall be for use with 119re continuously welded running rail, jointed rail, within special trackwork and insulated rail joints.
2. The fastener shall consist of as few components as economically and technically feasible for ease of assembly, disassembly and maintenance in the field.
3. The anchor bolt shall be capable of being removed and installed using a socket wrench or vertical bolting machine, without removing the rail clip.
4. When installed in track it shall not be necessary to raise the rail more than 1-1/2 inches to remove or install the fastener.
5. Welding shall not be used in the fabrication or assembly of the fastener nor any fastener component.
6. Except for SPDF fasteners used under switch points and stock rails, there shall be no specific field or gauge side to the fastener.
7. Longitudinal restraint properties of the fastener shall be identical in both longitudinal directions. Lateral restraint properties of the fastener shall be identical in both lateral directions.
8. Rail fastener shall provide a means of adjusting the rail laterally within a range of plus or minus 1 inch in increments of 1/8-inch or less. The lateral fastener adjustment shall be integral with the fastener anchorage assembly. Lateral or longitudinal stability of the rail shall not be reduced in any adjustment position. All requirements of these specifications shall be satisfied for all increments of adjustment of the fastener. Friction alone shall not be used as a means of adjustment. Lateral adjustment shall be by a method that does not require removal, substitution or addition of any fastener components.

9. If serrations are used for lateral rail adjustment, not less than three interlocking serrations shall be engaged in any position of lateral adjustment. The bottom plate serrations shall be an integral part of the bottom plate.
10. A lot and fastener numbering system shall be developed for marking each fastener. A lot number, daily production identification number, and manufacturer's name or trademark shall be permanently and clearly stamped or molded on the top of each fastener. The marking shall be readily visible in the installed position. The location and method of marking of identification data shall be shown on the Shop Drawings.

D. Fastener Body Requirements

1. The rail fastener body shall consist of an elastomeric pad bonded between metal top and base elements. Bonding shall use the vulcanization process.
2. The metal top and base elements shall be designed with sufficient material strength, thickness and shape to withstand the loading requirements of the specifications and the transit system.
3. The metal top element shall have a flat rail-bearing surface in the center of the fastener that supports the rail directly without intermediate pads or shims beneath the rail and without rail cant. The rail seat area shall be flat to provide a uniform bearing surface. The rail shall rest on the rail seat without rocking, or other indications of non-uniform mating between the rail base and the rail seat surface with rail clips removed.
4. Shoulders which position and secure the rail against lateral movement, both with and without the rail clips installed, shall be integral with the metal top element along the entire rail bearing surface and shall be set parallel on both sides of the rail base. Width between shoulders at the rail base shall be 5-9/16 inches.
5. The bottom of the fastener shall be parallel to the rail seat so as to provide no cant to the rail.
6. The bottom of the fastener shall be flat and without any downward projections.
7. The stability of the rail fastener in any lateral and longitudinal direction shall not be solely dependent on the strength of the bond of the elastomer to metal.
8. The fastener's metal top and base elements shall have full bearing on the elastomer pad in all positions of lateral fastener adjustment.
9. The fastener design shall be such that the elastomer is fully bonded to all parts except for the detachable components.
10. Bonding of any part of the fastener to the rail or track concrete is prohibited.
11. All metal surfaces of the fastener body's top and bottom elements that are not covered with elastomer shall be coated with the adhesive used to form the bond of elastomer to metal.

12. The bottom of the base element shall be free of elastomer except that minimal flashing of bonded elastomer, not exceeding 1/32 inch in thickness, will be acceptable providing it does not interfere with retention of proper anchor bolt tension nor otherwise interfere with the performance of the fastener.
13. The rail seat area of the top element shall be free of elastomer except that minimal flashing of bonded elastomer, not exceeding 1/32 inch in thickness, will be acceptable providing it does not interfere with the performance of the fastener, and it allows full contact of the rail with the rail seat.
14. Except within the rail seat area and on the fastener bottom, loose, unbonded flash not extending out greater than 1/4 inch from a bonded surface, will be allowed.
15. The elastomer pad shall not be thinner than 5/8 inch.
16. The load deflection on SPDF fasteners of the elastomer shall not exceed 25 percent of its uncompressed thickness for a load of 15,000 pounds applied vertically to the rail in a fully assembled rail fastener. Precompression of elastomer in rail fasteners in the installed position shall be included in determining the total compressive strain.
17. No mechanical metal distortion during the molding process is allowed.
18. Polyethylene base pads indicated shall conform with ASTM D1248, Type III, Class C, Grade W8, for high-density polyethylene plastic with a durometer hardness of 60 to 65D. The hardness shall be stable between plus 140 degrees F and minus 40 degrees F. Submit a certificate of compliance.

E. Fastener Anchorage Assembly Requirements

1. DF fastener bodies shall be secured to the track concrete with two anchorage assemblies, one on each side of the rail. The anchorage assemblies shall be located as shown in Figure 1. Each anchorage assembly shall consist of an anchor bolt, anchorage insert, lock washers, washers and other components required for lateral adjustment of the fastener.
2. SPDF fastener bodies shall be secured to the track concrete with four anchorage assemblies, two on each side of the fastener. Each anchorage assembly shall consist of an anchor bolt, anchorage insert, lock washers, and washers. Other components required for lateral adjustment of the fastener shall be provided. Lateral adjustment feature of the fastener shall be a part of the fastener anchorage assembly.
3. The anchorage assembly shall anchor the metal base element to the track concrete, with a 7/8 inch diameter anchor bolt. The anchor bolt shall be threaded into a female-type anchorage insert embedded in the track concrete perpendicular to the fastener base. Anchor bolts shall not penetrate the metal top element.
4. The fastener shall provide a means of adjusting the rail laterally within a range of plus or minus 1 inch in increments of 1/8 inch. The means of lateral adjustment shall be integral with the fastener anchorage system and shall not require removal, substitution or addition of components. Lateral adjustment shall also not require the movement of an anchor bolt laterally. Friction alone shall not be used as a means of

adjustment. Lateral or longitudinal stability of the rail shall not be reduced in any adjustment position. All requirements of these specifications shall be satisfied for all increments of adjustment of the fastener.

5. The anchorage assembly shall not permit more than 1/8 inch total lateral movement of the fastener relative to the concrete trackbed when the anchor bolts are finger tight.
6. Serrations used for lateral rail adjustment, not less than three interlocking serrations shall be engaged in any position of lateral adjustment. The bottom plate serrations shall be an integral part of the bottom plate.
7. The anchor bolt shall be capable of being removed and installed, using a socket wrench, without removing the rail clip.
8. Each anchorage assembly shall require a lock washer.

F. Electrical Insulation Requirements

1. The fastener design shall provide a 3/4 inch minimum electrical leakage distance under all load and adjustment conditions. The electrical leakage distance shall be measured from any grounded portion of the fastener to any charged portion of the fastener by the most direct path that does not pass through insulating material. The leakage distance path shall exclude recesses and other geometric configurations that are susceptible to collecting and holding moisture, dust, and other electrically conductive materials.
2. Recesses or notches which penetrate the metal top element and expose the elastomer shall be free draining at all values of track superelevation from 0 to 8-1/4 inches if draining in a direction perpendicular to the rail and at all values of track profile grade from 0 to 4 percent if draining in a direction parallel to the rail.
3. Fastener surfaces shall be resistant to conductive oil and dirt buildup and facilitate effective periodic cleaning by track maintenance equipment and personnel.
4. Exposed metal surfaces on the sides of the fastener shall be covered by at least a 1/16 inch of the same elastomer as used in the fastener body. The elastomer covering shall be securely bonded to the metal surfaces during the same vulcanization process as the rest of the elastomer.
5. The minimum resistance for 500 V dc shall be 10 MΩ when dry and 1 MΩ when wet.
6. The minimum impedance for frequencies between 20 Hz and 10 kHz with 50 V ac shall be 10 kΩ when wet.

G. Vibration Isolation Requirements

1. The rail fastener shall be designed to attenuate vibration forces transmitted to the concrete trackbed by vehicle operation on the rail.

2. The elastomer used to attenuate vibration forces shall be fully bonded to both the metal top element and the metal base element. Separate resilient pads placed between rail base and the fastener rail seat or between the fastener base and concrete trackbed, or separate elastomeric washers under the anchor bolt, shall not be permitted.
3. The vibration isolation performance of the fastener shall not be compromised in any position of lateral adjustment.
4. Dimensions affecting the shape of the elastomer in the fastener shall be determined by the manufacturer so that the complete rail fastener conforms to the physical requirements and acceptance criteria for all fastener tests.

H. Fastener Installation

1. The anchor bolt shall be capable of being removed and installed, using a socket wrench or vertical bolting machine without removing the rail or rail clips. Special tools developed to perform a unique function related to the fastener or not available from commercial sources shall not be permitted.
2. For height adjustment during installation, one or two shims of variable thickness shall be placed by the installer between the fastener base and the concrete trackbed to provide for vertical adjustment to compensate for construction tolerances and variations. The nominal design thickness of the shim shall be 3/8 inch. The Contractor may vary the shim thickness from a minimum of 1/8 inch to a maximum of 1/2 inch in 1/16 inch increments. The shims shall be high-density polyethylene conforming to the specifications herein. The Contractor shall provide all shims, including those shims required for fastener testing.
3. The Contractor shall place the fasteners upon a 1:40 canted reinforced concrete trackbed. The concrete will have a 28 day compressive strength of 4,000 pounds per square inch. The female-type anchorage inserts will be cast into the concrete during the pour spaced beforehand to match the anchor design of each fastener and fastener spacing along each rail. They will be set perpendicular to the top of the track concrete so that the top face of the insert is flush with the top surface of the concrete. The Contractor shall ensure that the top surface of the concrete is flat and free of cavities and voids. Concrete forming tolerances will match those required of the concrete test block for the fastener tests. Bonding agents for application to base of fastener, to shims, or to concrete surface during installation shall not be permitted.
4. A relative installation tolerance between adjacent top of shim bearing surfaces of 1/16 inch will be allowed.
5. The Contractor shall submit a set of instructions, approved by the manufacturer, for installation and replacement of the fasteners in-track. The instructions shall describe the proper method of assembly and installation that shall be followed by the installer to ensure optimum performance and longevity of service. The component assembly and installation specifications and instructions provided in the installation requirements shall be in total agreement with the approved fastener as-built drawings and the installation conditions used for the fastener assembly qualification

testing on the concrete test block. As a minimum, the installation instructions shall include the following.

- a. Installation procedures
- b. Installation drawings
- c. Anchorage insert care and installation
- d. Shim thickness and placement restrictions
- e. Lateral adjustment method
- f. Anchor bolt torquing requirements
- g. Allowable tolerances
- h. Installation tools required
- i. Installation requirements at bonded insulated joints
- j. Installation requirements at rail joints

I. General

1. All fastener components shall comply with the minimum standards set forth herein.
2. All surfaces of materials shall be free of gaps, burrs, sharp edges, wrinkles, waves, blemishes, or other unsightly or unsafe defects that detract from a neat appearance of the finished product.

J. Metal Components

1. The metal top and base elements shall each be one-piece rolled, forged or cast steel or ductile iron.
2. The rail seat and clip mating surfaces of the top element shall be smooth, free from injurious warp and other imperfections in surface and projecting fins of metal caused during forming.
3. Ductile iron castings shall be minimally Grade 65-45-12 in accordance with ASTM A536. The chemical composition shall meet the acceptable level per SAE J434. The Brinell hardness in accordance with ASTM E10 shall be within the limits set by SAE J434. The microstructure shall be within the limits set by SAE J434. The fracture energy at 21.1 degrees C in accordance with ASTM E23 shall be equal to or greater than 3 foot-pounds.
4. Rolled steel plate shall be minimally ASTM A36/A36M steel. The fracture energy at 21.1 degrees C in accordance with ASTM E23 shall be greater than 15 foot-pounds.

K. Elastomer

1. The elastomer shall be natural rubber based as defined in ASTM D1566 and herein. Natural rubber based elastomer shall be defined as being 100 percent natural rubber or a blend with over 50 percent natural rubber. The manufacturer shall formulate the elastomer based on successful long-term case histories in similar service conditions to the BART System.
2. Except as required to meet the requirements for identification markings, exposed elastomer surfaces of the finished fastener shall be smooth with a finish and appearance equal to or better than an F-3 designation in accordance with RMA Rubbers Handbook.
3. The Durometer A hardness shall be between 40 and 70 as measured in accordance with ASTM D2240.

L. Anchor Bolts

1. The anchor bolts shall be 7/8-9 UNC heavy hex structural bolts of the following material in accordance with ANSI B18.2.1.
 - a. ASTM A325, Type 1, zinc coated, or
 - b. SAE J429, Grade 5, zinc coated.
2. The threads shall be the Unified Coarse Thread Series with a Class 2A tolerance in accordance with ANSI B1.1 and ANSI B1.3.
3. The length shall be sufficient to provide at least 1-1/2 inch thread engagement with the anchorage insert threads when the fastener is installed at the maximum vertical adjustment, using 1 inch of shims.

M. The washers shall be 7/8 inch diameter of the following material.

1. Hardened steel washers in accordance with ASTM F436. Carbon steel washers shall be zinc coated. Weathering steel washers shall be supplied for use with ASTM A325, Type 3 bolts.
2. Plain washers in accordance with ANSI B18.22.1, Type B, regular, zinc coated.
3. Lock washers in accordance with ANSI B18.21.1, helical spring, extra duty, zinc coated.

N. Anchorage Inserts

1. Anchorage inserts shall be nonwelded, female type, and shaped as required to prevent rotation and pullout. The total length shall not exceed 5-1/2 inches. The insert shall remain within the envelope indicated on Figure 1 in all positions of adjustment.
2. The inserts shall be threaded to receive the anchor bolts using 7/8-9 UNC-2B threads in accordance with ANSI B1.1. For anchorage inserts to receive zinc coated

bolts, the pitch diameter shall be increased to account for the zinc coating thickness. The allowance for the pitch diameter shall be six times the minimum zinc coating thickness specified. The threads shall be coated with a rust inhibitive to prevent rust formation during preinstallation storage yet which will not hinder the threading on and tightening to proper torque of the anchor bolts during installation in track. The rust inhibitive shall be indicated and specified on Shop Drawings for approval by the Engineer.

3. The top of the insert in the installed position shall have a smooth and flat bearing surface. The bearing surface shall have a minimum area of one square inch.
4. A nylon or plastic pull-away type plug capable of sealing the insert threads against concrete seepage that is easily removable shall be provided with each insert.
5. The insert shall be made of one of the following materials.
 - a. SAE J429, Grade 5 steel.
 - b. Carbon steel with 0.50 percent maximum carbon and hardness in the range of 248-352 BHN (or 24-38 HRC).
 - c. Ductile cast iron, Grade 65-45-12, in accordance with ASTM A536.
6. All inserts shall be coated with a fusion bonded epoxy. The fusion bonded epoxy coating shall be Scotchkote 206N, as manufactured by 3M Company; Scotchkote 134, as manufactured by 3M Company; Nap-Gard 7-2500, as manufactured by O'Brien Corporation; or equal.
7. The fusion bonded epoxy coating shall be applied to all surfaces of the insert, except for the threaded "hole" which must remain uncoated. The coating shall be applied in accordance with ASTM A775/A775M, except for the following modifications.
 - a. The coating shall be applied by either the electrostatic spray method or the fluidized bed method, as recommended by the epoxy manufacturer.
 - b. Prior to surface preparation, oil and grease shall be removed by solvent cleaning, vapor degreasing, or steam cleaning in accordance with SSPC SP1.
 - c. The fusion bonded epoxy coating shall be applied in accordance with the coating manufacturer's latest published instructions.
 - d. The dry film thickness shall be 12 mils minimum to 30 mils maximum. The thickness shall be measured with a magnetic thickness gage.
 - e. The coating shall be uniform and free of runs, sags, or chips. The coating shall meet the discontinuity (holiday) test requirements herein.
 - f. The bend test specified in ASTM A775/A775M is not required.

O. Polyethylene Pads/Shims

1. Polyethylene shims shall conform to ASTM D1248, Type III, Class C, Grade W8 for high-density polyethylene plastic with a durometer hardness of 60 to 65D. The hardness shall be stable between + 140 degrees F and - 40 degrees F.
2. The nominal thickness of the pad shall be 3/8 inch. The Contractor may vary pad thickness from a minimum of 1/8 inch to a maximum of 1/2 inch in 1/16 inch increments. Test shims shall be 3/8 inch thick.
3. The shims shall provide a 1/2 inch projection beyond the sides of the fastener perpendicular to the rail and a one inch projection beyond the sides of the fastener parallel to the rail. Anchor bolt holes in the shim shall be located at each bolt location. The hole shall be one inch in diameter.
4. The shims shall be used for qualification and production quality control tests and delivered to the Engineer after the testing is complete.

P. The following coating shall be used for metal components when specified.

1. Hot dip galvanizing in accordance with ASTM A153.
2. Mechanical zinc galvanizing in accordance with ASTM B695, Class 55-110.

2.04 GENERAL PRODUCTION

- A. Production of direct fixation fasteners or components prior to the Engineer's review and approval is prohibited.
- B. Manufacture all direct fixation fasteners using the same methods used to produce qualification test pieces.

2.05 SOURCE QUALITY CONTROL

- A. Production quality control inspection and testing shall be as specified herein.
- B. Production Testing
 1. Production quality control tests shall be performed during fastener manufacture to verify that the fasteners meet the requirements of these Specifications.
 2. Perform all inspections and tests in accordance with the approved test program plan.
- C. Elastomer Production Testing
 1. The Contractor shall require the manufacturer to perform all inspections and tests specified herein on each of two samples certified to have been taken from the first production size batch of elastomer used in the manufacture of the initial fastener production lot of 50 or more fasteners and having an equivalent degree of cure to the fastener elastomer. Use a separate pair of samples for each test. The elastomer batch shall meet the acceptance criteria for all the elastomer tests as specified herein.

2. After the first production size batch, the manufacturer shall perform the inspections and tests specified below on each of two samples certified to have been taken from the elastomer batch used in the manufacture of each fastener production lot and having an equivalent degree of cure to the fastener elastomer. Use a separate pair of samples for each test. The elastomer batch shall meet the acceptance criteria for the following tests as specified in herein.
 - a. Hardness Test
 - b. Tensile Strength and Ultimate Elongation Tests
 - c. Tear Resistance Test
 - d. Rheology (Cure and Strength Indicator) Test
 - e. Specific Gravity Test
3. Should any elastomer sample fail to meet the test requirements, the entire elastomer batch shall be rejected and the entire fastener production lot manufactured from the rejected elastomer batch shall also be rejected.
4. Should an elastomer batch be rejected, the manufacturer shall perform all tests and inspections specified herein on each of two samples certified to have been taken from the next production size batch of elastomer used in the manufacture of fasteners and having an equivalent degree of cure to the fastener elastomer. Use a separate pair of samples for each test. The elastomer batch shall meet the acceptance criteria for all the elastomer tests as specified herein.

D. Anchorage Assemblies Production Testing

1. Test Method
 - a. A discontinuity (holiday) test shall be performed on each anchorage insert produced, in accordance with NACE RP0188, at the fusion bonded epoxy applicator's plant using a high voltage holiday detector at 2 kV. The test shall be performed with a brass brush on the stem.
 - b. As an alternative a discontinuity (holiday) test shall be performed on each anchorage insert produced using a low voltage holiday detector at 9 V to 100 V dc. The test shall be performed using an electrolyte solution.
2. Any piece having holidays shall be rejected, however, repair of one minor holiday per insert shall be permitted. Repaired inserts shall be retested as specified above, and the repaired insert shall be free of holidays upon repair. Any repaired inserts that fail the retest shall be rejected. An insert shall be repaired and retested only once. Any repaired inserts that fail the retest may be stripped of all coating, recoated as specified herein and retested as specified herein. The repair method shall conform to ASTM A775/A775M. The Contractor shall submit the proposed repair method with the test procedure for approval by the Engineer.

E. Fastener Production Testing

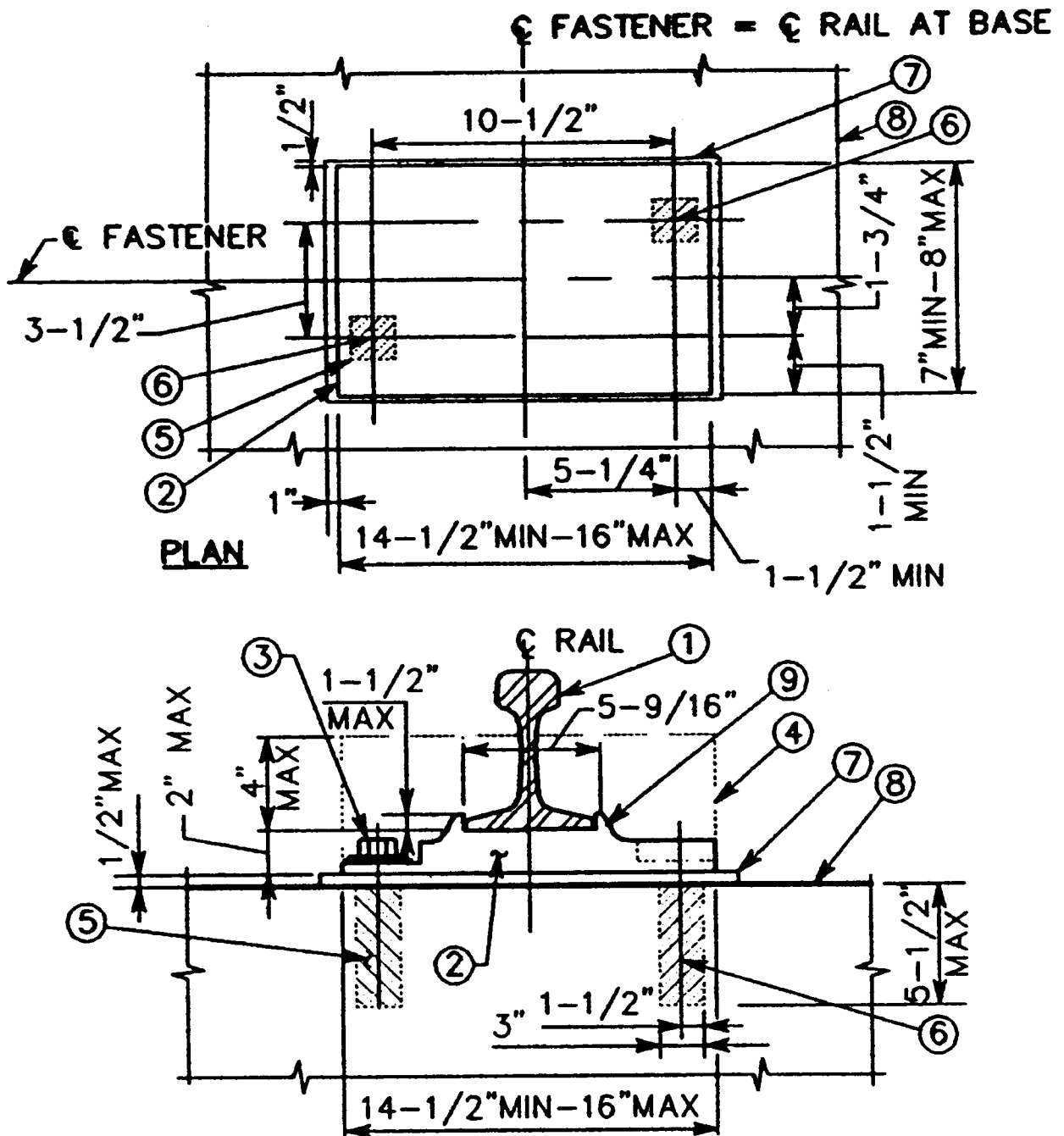
1. Production quality control testing of fasteners shall be performed on two fasteners from the first 50 fasteners produced and on two fasteners from each production lot. A production lot is defined as a quantity of manufactured and completed fasteners produced in a continuous run, but not to exceed 5,000 units. Fasteners shall be selected for testing by the Engineer.
2. All production quality control tests for each particular production lot shall be successfully completed and the test reports for the tests approved by the Engineer before that production lot will be accepted. Should either fastener fail to meet the test requirements, two additional fasteners from the same production lot shall be subjected to the complete set of production quality control tests. If either of the second pair of tested fasteners fails to meet the test requirements, the entire production lot shall be rejected or tested and only those fasteners that successfully pass the production quality control tests will be accepted. The cost of all such additional testing, including costs for the Engineer or a representative of the Engineer to witness the tests, of any fastener or fastener component that does not comply with these Specifications shall be at the Contractor's expense.
3. Fasteners used for production testing and meeting all test requirements shall be permanently marked as production test fasteners and shall be delivered separately to the Engineer.
4. Production quality control testing of fastener assemblies shall include the following tests as specified herein
 - a. Vertical Load Test
 - b. Vertical Uplift Test
 - c. Lateral Load Test
 - d. Lateral Restraint Test
 - e. Longitudinal Restraint Test
 - f. Electrical Resistance and Impedance Test
5. Contractor shall certify that all fasteners were manufactured in the same manner as the fasteners subjected to the Qualification Testing. Upon submittal of certification, the entire lot of fasteners will be released by the Engineer for shipment.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install direct fixation fasteners in accordance with the respective manufacturer's recommended installation instructions and procedures and as provided, except as modified herein.
- B. Install direct fixation fasteners in accordance with the requirements of Section 34 05 17 - Common Work Results for Trackway.

END OF SECTION 34 11 37



- | | |
|-----------------------|------------------------------|
| 1. 119 RE RAIL | 6. CENTER LINE - ANCHOR BOLT |
| 2. FASTENER BODY | 7. SHIM |
| 3. 7/8" ANCHOR BOLT | 8. CONCRETE TRACK BED |
| 4. FASTENER ENVELOPE | 9. SHOULDER |
| 5. ANCHORAGE ENVELOPE | |

FIGURE 1 - DF FASTENER CLEARANCE ENVELOPE

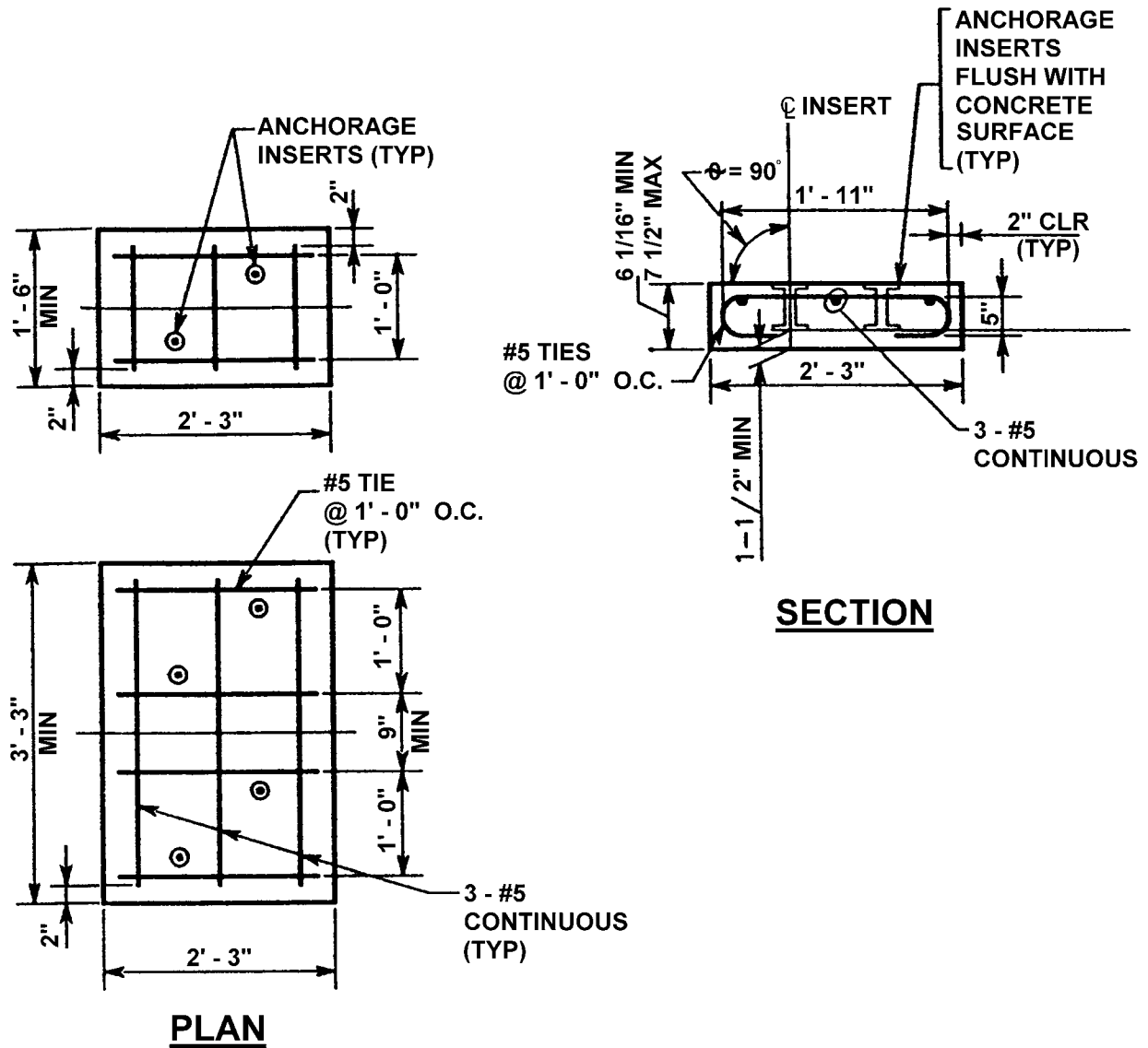


FIGURE 2 – DF CONCRETE TEST BLOCK

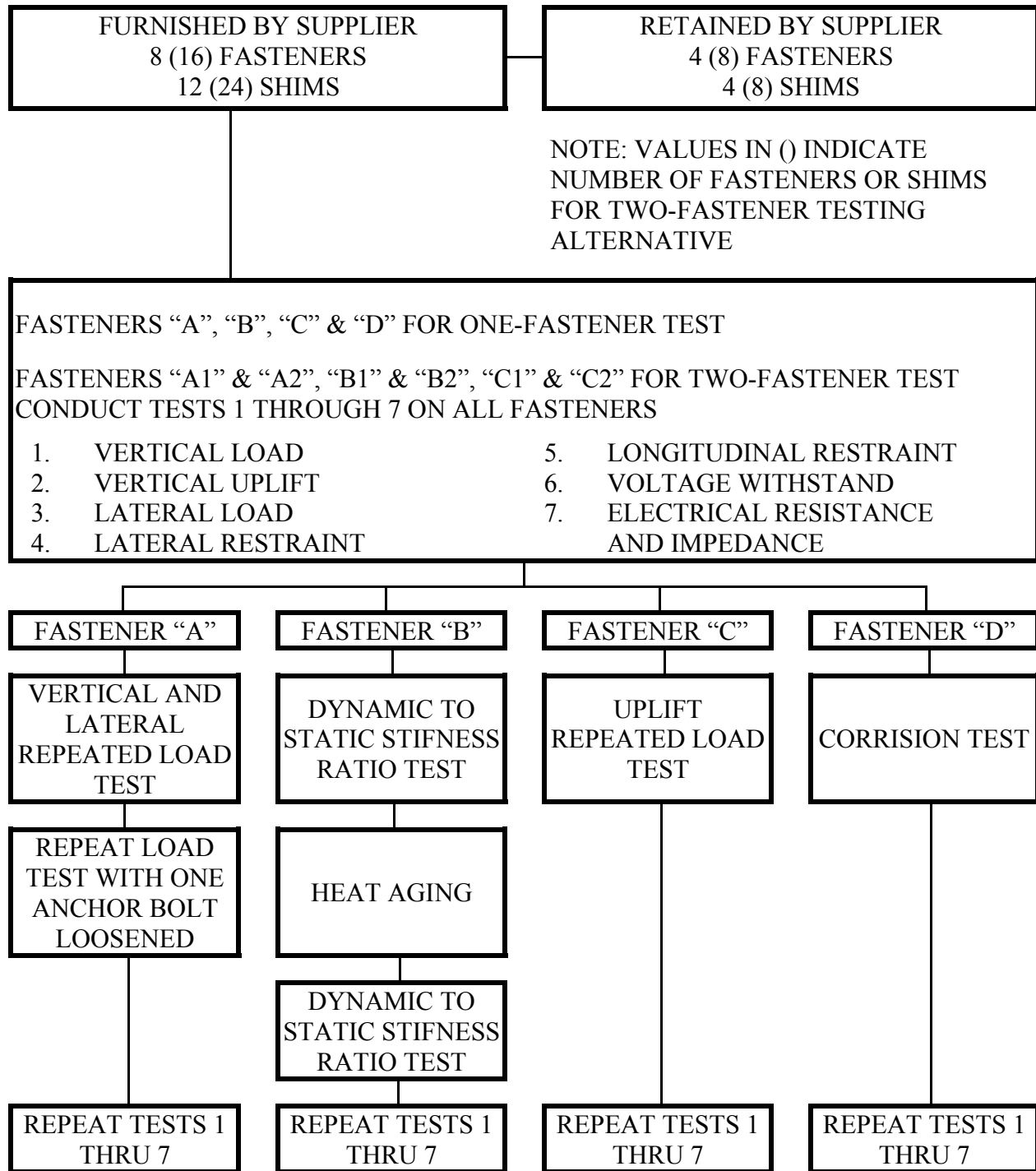
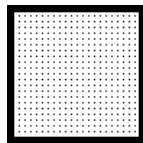
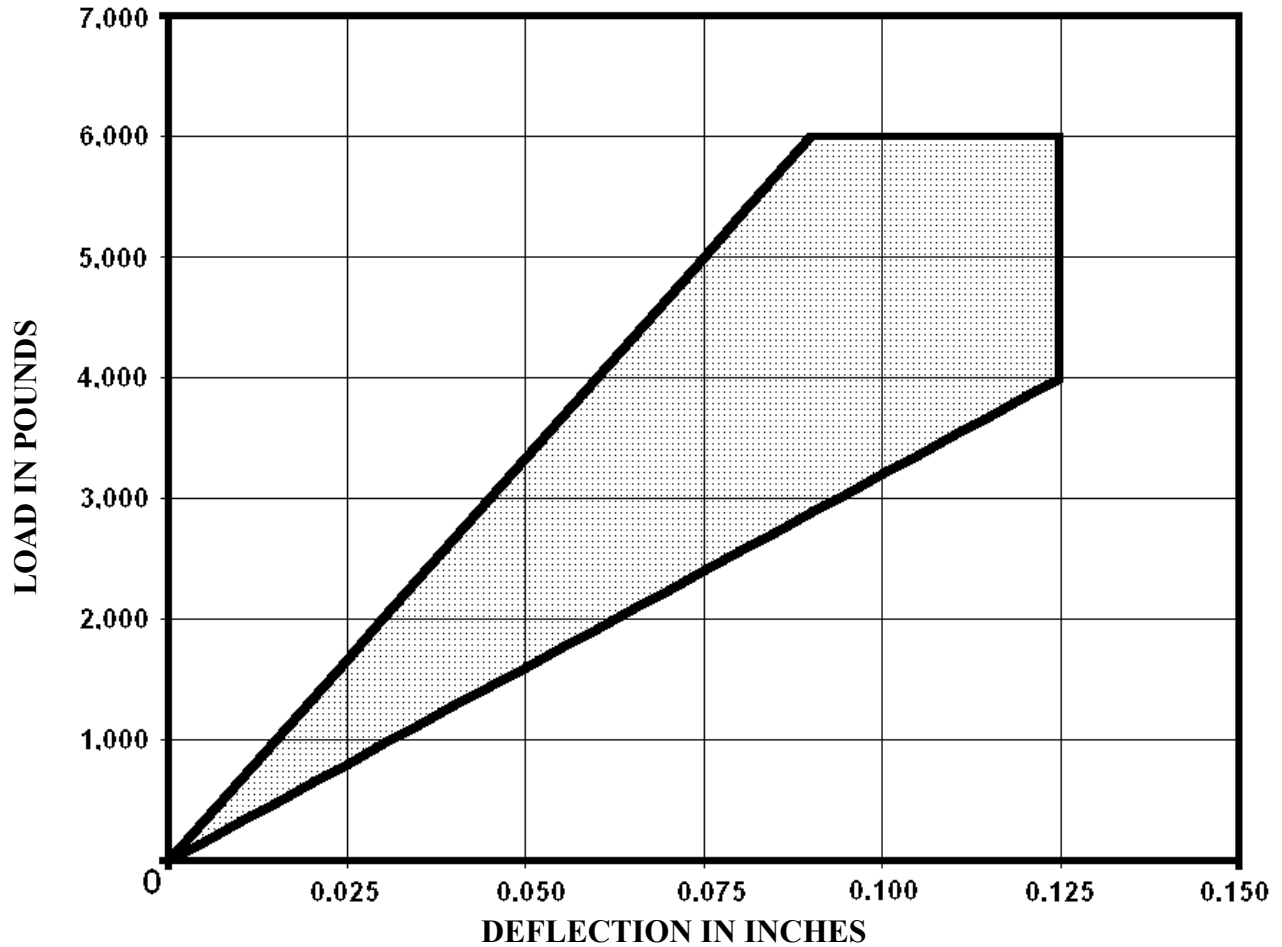


FIGURE 3 – FASTENER ASSEMBLIES QUALIFICATION TESTING SEQUENCE



ACCEPTANCE LOAD vs DEFLECTION ENVELOPE.
INDICATED SPRING RATES ARE ONLY FOR DEFINING
ENVELOPE OUTLINE.

**FIGURE 4 – LATERAL AND LONGITUDINAL RESTRAINT TEST ACCEPTANCE
CRITERIA**